

Ground-Ground Data Communication-Assisted Planning and Coordination: Shorter Verbal Communications

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A human-in-the-loop simulation was conducted to investigate the operational feasibility, technical requirements, and potential improvement in airspace efficiency of adding a Multi-Sector Planner position. A subset of the data from that simulation is analyzed here to determine the impact, if any, of ground-ground data communication (Data Comm) on verbal communication and coordination for multi-sector air traffic management. The results suggest that the use of Data Comm significantly decreases the duration of individual verbal communications. The results also suggest that the use of Data Comm, as instantiated in the current simulation, does not obviate the need for accompanying voice calls.

INTRODUCTION

The Next Generation Air Transportation System (NextGen) concept developed by the Joint Planning and Development Office outlines a transformation of air traffic management from the current system to one in which traffic is managed in a much more strategic fashion. Development of new technologies, such as digital data communication, better aircraft surveillance, and automation-supported conflict detection and resolution, is expected to support the transformation to trajectory-based operations. It also provides an opportunity to explore new team configurations that may better take advantage of the new technologies by reallocating the roles and responsibilities among the various air traffic service providers.

One concept under consideration modifies the standard team configuration within an air traffic facility (e.g. controllers, Area Supervisors, Traffic Management Coordinators, etc.) to include a new position called Multi-Sector Planner (MSP). There have been numerous investigations in the U.S. and Europe (Herr, Teichmann, Poppe, & Sharez, 2003) exploring different variants on the MSP position with the common assumption that in the future air traffic environment aircraft trajectories can be strategically managed across multiple sectors.

The current investigation of the MSP position by the Federal Aviation Administration examines the MSP who performs the functions often associated with traffic flow management but works the traffic at a much closer time horizon and by

manipulating individual aircraft trajectories. In this concept, the MSP assists with trajectory and flow management functions by assessing traffic complexity and flows across several sectors and within an effective planning timeframe between approximately 30-60 minutes and then rerouting aircraft to manage the complexity and/or redirect the flows around traffic constraints (e.g., weather cells). Working at a time horizon less immediate than that of the sector controller but closer in time than the Traffic Management Unit, the MSP has the potential to reduce delays and provide more efficient route options when aircraft must be rerouted.

A large-scale human-in-the-loop simulation investigating the operational and technological requirements and feasibility of the MSP concept was carried out in 2009. The current study examines a subset of the data from the larger simulation, namely, the verbal and data communication and coordination between MSPs and a Traffic Management Coordinator (TMC).

Rationale for the Current Study

One of the key feasibility questions for the MSP concept has been whether the extra coordination layer, created by adding MSP positions to the existing team configuration, would result in an unmanageable amount of required coordination. Given that one of the main MSP functions is to create and send 4-D trajectory reroutes, we hypothesized that the availability of ground-ground

digital data communication (Data Comm) that can send and receive route trajectories would offload verbal communication and coordination, thus increasing feasibility.

There are several features of Data Comm, in particular the ability to create and send graphical 4-D trajectory reroutes on one or more aircraft, which may be suited to facilitating verbal communication. For one, the visual modality is particularly useful for spatial communication. Verbally describing 4-D trajectories, particularly those based on lat/long coordinates and not restricted to pre-defined VORs, waypoints, or fixes, can be cumbersome at best. Having a common visual reference might also reduce the number of miscommunications and consequent verbal clarifications. Further, the use of Data Comm tools like those in the current study can facilitate the aircraft identification process by providing immediate visual feedback on the aircraft and routes that have been sent, thereby eliminating the typical pause in verbal communications while one party searches for the target aircraft.

In this study, we asked participants to verbally coordinate trajectory/flow plans with everyone impacted by the plan. Given this procedure, Data Comm was not likely to significantly reduce the total number of coordination requests, but it could reduce the duration of verbal communications. Therefore, we hypothesized and tested whether voice communications supported by Data Comm were shorter than those not supported by Data Comm.

METHOD

The data reported here are taken from a larger study conducted in 2009, a description of which is beyond the scope of the current report; only the relevant methods are described here. A comprehensive report on the simulation in its entirety is currently in preparation.

Simulation Facilities

The study took place in the NASA Ames Research Center Airspace Operations Laboratory (AOL) using the Multi-Aircraft Control System (MACS) simulation platform (Prevot et al., 2006). MACS has been used to quickly prototype NextGen

functions to support numerous concept evaluation simulations. All of the basic controller functions for today's operations are available in MACS but it also augments the displays to include anticipated NextGen functions such as conflict probe and Data Comm.

In order to support the MSP study, MACS displays were expanded further to include a suite of MSP tools. This prototype workstation included a Traffic Situation Display with predicted weather information and an interactive display which could be used to filter aircraft, construct routes, and coordinate the routes with others. The MSP workstation also provided tabular and graphical displays of current and predicted load and complexity for all sectors within each MSP's Center. The prototyped tools provided, among other functions, the ability for graphical and/or keyboard user input multi-aircraft selection and trial route planning in an advanced operational air traffic management environment.

Most relevant to the current report, these tools allowed MSPs, TMCs, and Area Supervisors (Sups) to create new 4-D reroute plans for one or more aircraft and to communicate these plans to other MSPs, TMCs, Sups, and controllers via Data Comm. Additionally, a Voice Communication System (VCS) emulation allowed for verbal point-to-point and progressive conference calls between positions.

Training and Study Design

The MSP team participated in 4 days of training on the concept, operational procedures, and use of the tools and VCS. The data were collected over 2 full days of simulation, each consisting of 4, 75-minute runs. The simulation runs alternated between high traffic loads and convective weather problems.

The simulated airspace, staffed by four MSPs and one TMC, consisted of high altitude airspace of Kansas City Center (ZKC) and part of Memphis Center (ZME). The traffic and weather scenarios were designed to put the most pressure on the eastern half of ZKC. Therefore, eastern ZKC was split into a north and south half and assigned to one MSP each while western ZKC and northeastern

ZME were each assigned an MSP. The TMC's purview was all of ZKC.

MSP participants were instructed to monitor the 30-60 minute time horizon traffic situation and sector complexity within their respective areas of responsibility to ensure that controller workload remained within safe and manageable levels. If they determined reroutes were needed, they were asked to coordinate with each other, the Sups, and the TMCs as necessary, using the tools to plan, coordinate, and execute these reroutes. For the current purposes, ZKC TMC's role was similar though based on a further time horizon and also included maintaining the "big picture" and coordinating high-level plans.

For simplicity, communications with a second TMC, played by a confederate participant, are not included in this analysis. Communications with the Area Supervisors are also excluded from consideration here because they were of a substantially different nature, (e.g., per protocol, one Supervisor never received or sent Data Comm).

Participants

The relevant participants then were two Front Line Managers and two Supervisor Traffic Management Coordinators (the four MSPs), and a Traffic Management Coordinator (ZKC TMC), each with over twenty years experience in air traffic management.

RESULTS

Associating Data Comm with Voice Calls

In their speech, participants did not systematically make explicit reference to the fact that they were discussing a plan sent via Data Comm. Therefore, we started from the Data Comm messages, rather than the voice call transcriptions. For each Data Comm sent, the message initiator, recipient(s), timestamp, and subject aircraft call signs were extracted. Then, voice calls between the initiator and at least one recipient that preceded and followed the Data Comm by up to 10 minutes were checked for references to information contained in the Data Comm (e.g., "Hey [MSP] West, SWA364 just north of Tulsa there, if you could get him down

to 28,000 feet, [for] complexity in [sectors] 29 and 90."). The surrounding ten minute interval was chosen because Data Comm messages "timed out" and were deleted from the system if not acted upon within ten minutes.

Of the total of 356 Data Comm messages sent by TMC and MSPs over 8, 75-minute runs, 285 (80%) either preceded or followed a related voice call, while 66 (18.5%) were not associated with a voice call. An additional 5 (1.5%) would have been associated with a voice call but had been misaddressed, typically due to user typographic error. Voice calls pertaining to these last 5 messages not were coded as associated with a Data Comm message, since the intended recipient never received the message.

The total number of calls associated with Data Comm messages was 244. This number differs from the number of Data Comm messages associated with calls (285) because some calls covered multiple Data Comm messages at the same time. In 234 (96%) cases, at least one of the related Data Comm messages (if there were multiple associated with the call) was sent before the voice call was placed, and on average the voice call followed the Data Comm by about 30 seconds ($M = 28.9$ s, $S.D. = 15.3$ s).

Data Comm-Supported Voice Calls

Given that conference calls were in general longer and were not often associated with Data Comm, we decided to only consider dyadic calls. We further narrowed our dataset to include only calls between MSPs or between an MSP and the TMC. Out the remaining 267 voice calls then, 135 (50.6%) pertained to a Data Comm message and 130 of those followed the Data Comm.

On average, calls that were preceded by Data Comm were significantly shorter than those that were followed by or unassociated with Data Comm ($N_s = 130$ and 137 , $M_s = 28.4$ s and 38.3 s, $S.D.s = 15.9$ s and 21.7 s, respectively; $F(1,266) = 17.89$, $p < .001$; Fig. 1).

Because the TMC sent many fewer Data Comm messages than the MSPs and might be expected to hold longer voice calls due to the greater scope of his responsibilities, we also decided to look at just MSP to MSP calls. Again, calls that were preceded

by Data Comm were shorter than those that were followed by or unassociated with Data Comm ($N_s = 97$ and 51 , $M_s = 24.3$ s and 29.2 s, $S.D.s = 10.0$ s and 16.4 s, respectively; $F(1,147) = 5.22$, $p < .05$; Fig. 1).

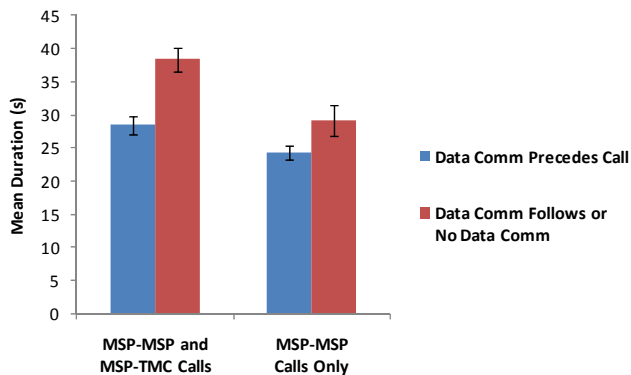


Figure 1. Mean voice call duration for dyadic calls that were preceded by and pertained to Data Comm and that were followed by or unassociated with any Data Comm. Error bars represent standard error of the mean.

DISCUSSION

Most MSP-MSP communication and coordination was carried out with the help of Data Comm. Consistent with their training, downstream MSPs tended to identify a predicted traffic or weather problem in their area of responsibility, develop a set of reroutes to solve the problem, and send those proposed reroutes via Data Comm to the upstream MSP responsible for the area where the subject aircraft were located. Data Comm was typically followed by a voice call from the downstream MSP to ascertain whether the upstream MSP was amenable to the request, would clear the request with the upstream Area Sup, and would forward the request on to the sector controllers.

Notably, the use of Data Comm for plan coordination decreased subsequent voice call length. This is probably in part because the Data Comm contained information that would otherwise need to be spoken. For example, instead of verbally describing a desired route modification, plan initiators could simply point recipients to a Data Comm. Once the recipient pulled up and viewed the graphical representation of the reroute, a simple “WilCo” was often all that was required. Data Comm also made it was easier for recipients to locate the subject aircraft. Rather than typing in one

or more aircraft call signs to bring up their flight data blocks and/or visually searching the display for the subject aircraft, the recipient could simply click on the received Data Comm message notification and thus bring up the 4-D trajectory.

While Data Comm appears to have facilitated communication and coordination, we cannot say whether it could have reduced the number of verbal communications since our protocol required verbal coordination. Consistent with the training we provided, the majority of Data Comm messages were accompanied by a voice call. One reasonable prediction would be that there would be fewer verbal communications when Data Comm was used, since participants could plan, propose, accept, and execute traffic initiatives all via Data Comm. However, there is reason to suspect that these supplemental voice calls would still have been necessary, even if they had not been formally required in this simulation. One reason for this is that it was not possible to embed the reason for a reroute request in the Data Comm itself. Another is that although participants could accept or deny requests via Data Comm, they could not embed an explanation for their acceptance or denial. Had participants been able to send their reasoning along with their request or response, perhaps with a brief text annotation like “To avoid Wx in ZKC 94” or “Reroute traverses overloaded ZME 25,” fewer voice calls might be necessary.

Another reason voice calls might have been necessary even with Data Comm, is because verbal conversation may have been more conducive to active negotiation. In its current instantiation, proposed 4-D reroutes sent via Data Comm needed to be accepted “as is” or denied. Participants did not have the option of modifying received reroutes, although they could chose to select and approve only certain reroutes out of a group received together. Therefore, verbal communication was needed so that the plan initiator could learn why his plan was rejected and what alternative reroute options were available to solve his traffic problem. One solution to these required voice calls might be to allow the Data Comm recipient to alter the reroutes in a way that works for his area and to send the modified Data Comm back to the original initiator for final sign-off. Again, it would be helpful if the recipient could know via Data Comm

what problem the reroutes were originally meant to solve.

Overall, the study suggests that Data Comm may offload verbal communication and coordination of reroute plans. While voice calls may not decrease in number, they decrease in length when preceded by Data Comm. Additional enhancements, some relatively minor, to the currently prototyped AOL Data Comm capabilities may further decrease the amount of verbal coordination required. It must be noted though that the current study was merely correlational and not an experiment proper, since access to Data Comm was not manipulated. Future research examining in a controlled manner the impact on verbal communication and coordination of the availability of Data Comm is warranted.

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